Effects of Equine Therapy on Malalignment-Generated Patellofemoral Syndrome: Targeting the Vastus Medialis Obliques

Undergraduate Honors Research Project

2003

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Introduction

At the onset of this project, a key point to keep in mind is that animal-assisted therapy (AAT) is regarded as still being in an early stage of professional development. This has a profound impact on its current research status. Animal-assisted therapy, as defined by the Delta Society, a prominent organization involved in AAT, is a method that uses animals as a means of therapeutic intervention for human problems (Grabois, Garrison, Hart, & Lehmkuhl, 2000). There have been significant amounts of research on topics in animal-assisted therapy over the last three decades; however, much of this research has been fairly limited in nature. For instance, most of the research has addressed outcomes regarding patients having cardiac conditions, i.e. decreased blood pressure, heart rate, and stress levels (Grabois et al., 2000). Similarly, the majority of studies report on effects of animals as pets only. For instance, it is well documented that pet owners have a longer life expectancy than persons who do not own pets, all other factors being equal. Throughout the scientific community there is a call for AAT research to become more quantitative as opposed to descriptive. Some general concerns at this time include conducting studies that will demonstrate a causal relationship between animal contact and human health in specific situations and conditions, include larger population groups for statistical analysis, and provide evidence that beneficial effects are responsible for more than just short-term improvements in physiologic parameters (Fine, 2000).

The specific condition under research in this case is patellofemoral syndrome as caused by malalignment. In current terminology, patellofemoral syndrome describes anterior knee pain, regardless of cause, and generally does not include gross anatomic changes in the patellar cartilage (Galea & Albers, 1994, p.53). Causes of anterior knee pain range from malalignment to trauma and overuse. A comprehensive list of classifications for patellofemoral syndrome can be found in Table 1.1. A large percentage of cases dealing with patellofemoral pain are caused by malalignment, which often correlates to a weakness of the vastus medialis oblique muscles. Patellofemoral syndrome is extremely common among the general population, perhaps because the knee is one of the most complicated joints in the human body, making it a particularly interesting injury to study. Patellofemoral syndrome may also serve to restrict daily activities such as going up and down stairs, running or jumping, and sitting for prolonged periods of time (Galea & Albers, 1994, p.54). Traditional therapy methods used to treat patellofemoral syndrome are ice, rest, and strengthening of the quadriceps muscle. Particular attention may be paid to an emphasis on isometric and graduated resistance (Galea & Albers, 1994, p.56). At this time, literature on patellofemoral syndrome is diverse and confusing, essentially because attempts to cite the origin of the pain are difficult. Persons experiencing patellofemoral pain may not have anatomic changes around the knee, but what is bewildering is that many asyptomatic people do have these changes (Galea & Albers, 1994, p.56). Therefore, pinpointing the symptoms and how they are affected by treatment is a key issue.

Equine therapy promises to offer a good avenue of rehabilitation regarding patellofemoral syndrome since the actions of muscle groups while riding a horse are precisely the areas that require strengthening. The three main gaits of a horse utilized by this study are walking, trotting, and cantering. All of these gaits employ the adductor muscles (inner thigh) as a means of stabilization, though some more than others.

Walking is essentially used as a warm-up tool, does not require a large amount of effort, and primarily engages the adductor muscle group. Trotting, on the other hand, is much more rigorous, since it involves an additional movement, known as posting, to maintain rhythm with the horse. Posting is characterized by standing and sitting while in the saddle and therefore engages not only the adductors but the extensor muscles as well. Finally, cantering is a fast-paced gait for a horse, requiring a higher degree of contraction from the adductor muscles to maintain balance. The degree of contraction from the extensor group is intermediate to that of walking and trotting. If any of these gaits were to be accomplished bareback, that is, without a saddle, the intensity would focus almost exclusively on the adductor muscles and increase in magnitude. Since weakness in the adductor and extensor muscle groups (vastus medialis obliques) is one of the main concerns when dealing with patellofemoral syndrome, it seems logical that an exercise program involving horseback riding should work to increase strength in those exact areas.

Problem Identification and Justification

A major contributing factor to the current status of animal-assisted therapy, a status characterized by a generic, broad range of beneficial health effects, is the "lack of research and references in the literature that detail AAT protocol or how it is actually conducted (Fine, 2000). Consequently, a large component of this project proposal is to establish a base knowledge of how animal-assisted therapy quantitatively affects the status of human health. Research regarding an animal-assisted therapy protocol is needed for a number of reasons. First of all, as indicated by a variety of sources, AAT has been shown to produce many desirable effects in patients who require physical therapy. In addition, AAT is becoming a more popular method of therapy throughout rehabilitation practices. Since there is a lack of research documenting a causal relationship between animal contact and human health in specific situations and conditions, studying the effects of equine-assisted therapy on patellofemoral syndrome, an extremely common affliction among the general population, is a particularly relevant issue. Plus, the general population stands to benefit both physically and emotionally by this research. While equine-assisted therapy may decrease the frequency of patellofemoral syndrome, it also provides a source of companionship and a creative means of focusing energy into therapy. The scientific community may benefit, as well, since this study could foster ideas for further research, especially in light of the fact that animal-assisted therapy is a growing field. In essence, a researched curriculum helps ensure that equine-assisted exercises are both effective and quantifiable regarding rehabilitation of persons with patellofemoral syndrome and vastus medialis oblique weakness.

Objectives

Research pertaining to the establishment of an animal-assisted therapy protocol must reflect upon a number of objectives. I hypothesized that equine-assisted exercises would positively affect patient outcome regarding patellofemoral syndrome. The main objectives are as follows:

1. To establish a causal relationship between animal contact and human health in a specific situation and condition, i.e. horseback riding exercise programs and their effect on patellofemoral syndrome
2. To track changes in the resistive strength of the knee region and the vastus medialis oblique muscles over the course of a series of modalities using muscle grade testing (scale:0-5 and pounds per square inch), range of motion scores (scale: degrees), and maximum output for weightlifting using adduction and extension (scale: lbs)
    a. To target the vastus medialis obliques throughout the horseback riding exercise programs, the muscles which are key both in horseback riding and patellofemoral syndrome
3. To provide a base of knowledge that will spark further research in the area of animal-assisted therapy

Procedures and Methods

The research design of this project represented a case study, consisting of a single-subject AB layout. In essence, this examined the status of the patient prior to (A) and following (B) therapeutic intervention sessions with equine-assisted therapy. There was no formal process to choose subjects; there was only one subject in this study, i.e. the co-investigator. There were a number of persons assisting throughout the research process: a veterinarian, a medical doctor, and a physical therapist. The animal-assisted therapy exercise programs were conducted on a regular basis, i.e. three days a week for a duration of five weeks. Each week's sessions reflected an exercise program containing elements of a horse's gait cycle, i.e. walking, trotting, cantering, and the challenging style of bareback riding. These exercise programs were designed to increase in intensity week by week in order to progressively challenge the vastus medialis obliques and the medial aspect of the supporting quadriceps femoris muscles. These exercise programs were also designed to reflect the comfort of the horse, allowing for adequate periods of rest and (or) periods of decreased intensity, i.e. walking or trotting. The exercise programs were:

Week 1:
Session 1: 30 minutes of walking at the horse's natural pace
Session 2: 10 minute walking warm-up, 10 minutes trotting, 10 minute walking cool-down
Session 3: 10 minute walking warm-up, 10 minutes trotting, 10 minute walking cool-down

Week 2: 5 minute walking warm-up, 10 minutes trotting, 5 minutes cantering, 5 minutes trotting, 5 minute walking cool-down

Week 3: 2 minute walking warm-up, 5 minutes trotting, 5 minutes cantering, 5 minutes trotting, 5 minutes cantering, 5 minutes trotting, 3 minute walking cool-down

Week 4: 2 minute walking warm-up, 2 minutes trotting, 5 minutes cantering, 2 minutes trotting, 5 minutes cantering, 2 minutes trotting, 5 minutes cantering, 2 minutes trotting, 3 minutes cantering, 2 minute walking cool-down

Week 5: 30 minutes of walking at the horse's natural pace (as stated for session 1), however this will be carried out bareback, a style of riding demanding much more stability and muscle strength **At minutes 15 and 30 there will be trotting for that particular minute

Note: Each week had a theme, that is, the sessions for each week were the same, excluding Week 1.

: Every session contained both a warm-up and cool-down period, not only for the horse's safety but for the subject's safety as well

: Each session was thirty minutes in length

These sessions were monitored using a wristwatch to observe particular time intervals. Prior to each session there was preparation, including the horse's grooming, saddling, etc. A pre-muscle grade test was administered by a certified physical therapist immediately prior to the riding session to get the most pure result prior to therapy. The thirty-minute session then took place. Following the completion of each session, a post-muscle grade test was given, again, by a certified physical therapist to assess any differences in muscle strength. The horse was then unsaddled, groomed, and fed a treat of either an apple or carrot. He was checked for any potential distress issues and then released to have the rest of the day off. As previously mentioned, this was the routine for each of the fifteen sessions; the only difference was in the content of the exercise program for each particular session. Manual muscle grade tests were measured on a scale of 0-5, 0 meaning an absence of resistance and 5 meaning resistance against a maximal effort. (See Table 1.2) Muscle grade tests by machine were measured in pounds per square inch. An additional measurement was recorded at pre- and post therapy times – a maximum output for weightlifting using adduction and extension (scale: lbs). Maximum output refers to the greatest amount of weight that can be lifted for one repetition. These measurements were made using standard weight room equipment, i.e. an adduction machine for the inner thighs and an extension machine for the quadriceps. By measuring the amount of weight lifted by the inner thighs and quadriceps, both members of the vastus medialis oblique group, it was possible to gain an objective measure of strength improvement. Finally, there were measurements taken using a goniometer to assess the range of motion at the patellofemoral joint. A goniometer is an angle measurement tool, similar to a protractor, used regularly by physical therapists. It is placed next to the body at the joint in question and pivots with the joint in order to determine the amount of flexion or extension at that particular joint. These measurements included both active and passive ranges of motion (scale: degrees). (See Table 1.3) However, range of motion measurements were only taken on a weekly basis, i.e. one taken prior to session one and one taken post-session three.

Table 1.2 – Scale for Manual Muscle Grade Testing

Number	Keyword	Description
0	Absent	Observation/Palpation of the Tendon
1	Trace	Observation/Palpation of the Tendon
2	Poor	Full Range in Gravity-Eliminated Position
3	Fair	Full Range Against Gravity
4	Good	Resisting Moderate Amount of Resistance Against Gravity
5	Normal	Resisting a Maximal Effort

Table 1.3 – Types of Action When Testing Range of Motion

Type	Description
Passive	Examiner moves joint to greatest tolerable range
Active	Patient moves through full range of possible motion

Throughout the application of these exercises, thorough notes were taken on all interactions between subject and horse, observations of exercise completion, and other data measures relevant to subject progress, such as subject testimonials regarding functional capacity.

At the conclusion of the research, all progress reports were organized, including measurements of muscle grade, maximum output, and range of motion, in order to gain a clearer understanding of any impact made by the animal-assisted therapy program. The objective measures taken pre- and post-session were plotted and analyzed to detect underlying changes in progress, whether they indicated improvement or depression. Statistical analysis will be done to calculate the correlation between measurements and time. Based on the temporal summation of the data, the equine-assisted therapy curriculum was assessed for further research purposes. A successful protocol should include all aforementioned goals and address all said concerns regarding individualization and effectiveness of the program.

Results and Discussion

My study focused primarily on the physical effects of equine therapy on patellofemoral syndrome; therefore, the measurements taken throughout the duration of this study were those most pertinent to the symptomatic aspects of patellofemoral syndrome. To start with, there were no concrete data trends available from measuring the range of motion at the knee joint. The subject was observed at the initial evaluation as having a normal range of motion with respect to all defined directions.[1] She maintained a normal range of motion throughout the study. The second measurements taken reflected the resistive power generated by the extensor muscles. The most medial extensor muscle is a part of the vastus medialis obliques, the main muscle group affected by patellofemoral syndrome. Reflected in Table 1.4, the muscle testing measurements, taken via an isokinetic machine, yielded a slight grade of improvement, though it is minimal at best.[2] Both direct weight measurements, however, gauged by maximum power output, indicate sizeable improvements over the duration of the treatments, especially considering the subject's isolation from any other knee strengthening activity. The data points display a consistent increasing pattern with no drawbacks or depressions. The graphs that present the maximum power output data for extension and adduction are available in Table 1.5 and Table 1.7 respectively.[3] There is one section of the extension data in particular that stands out against the overall picture. In the second week of testing, there is a jump of five pounds from pre- to post-measurement rather than the typical two-and-a-half pound increase seen elsewhere in the data. The adduction data shows consistent increases across the five-week period, as well. Increases in the maximum weight lifted were generally seen at the beginning of each week's session rather than during the measurements taken within the week.

Subjective changes indicated by the subject were also noted. These included less stress felt when performing the extension resistance tests and less strain in the knee region when ascending flights of stairs. These observations imply an increased degree of strength in the region of the knee, especially with respect to the stabilizer muscles and vastus medialis obliques. Though these improvements are purely subjective, they do represent an improvement in functional capacity, which is the goal of any rehabilitative therapy program.

Viewing the general trends in the data and considering the circumstances of the project, I feel confident in stating that the main objectives of this study were met with a promising degree of improvement. While not all of the data present a strong positive correlation, the extension resistance data specifically, the other trends provide overwhelming support that the equine therapy exercise programs were related to the strength increase seen in the area affected by patellofemoral syndrome. In addition, the vastus medialis obliques were targeted as planned, resulting in significant improvement for the extensor and adductor muscle groups. The percent increases in strength seen in the extension and adduction strength exercises are strikingly high at 53 percent and 46.6 percent respectively.

That the extension resistance data does not show a similar correlation warrants an explanation. According to the physical therapists I work with, as well as current literature in the field, the isokinetic machine used to measure resistive strength can be unreliable since the resistance offered is always equal to the force applied (Davies, 1984).

Therefore, differences in the patient from treatment to treatment can affect data, such as fatigue, level of motivation, etc. Problems with muscle group stabilization and smoothness of machine movement prevent this data from contributing greatly to potential correlations in any study. Nevertheless, the data showed a positive correlation of 0.72097 and a 4.6 percent increase in resistive strength from the stabilization period to the end of the study.[4]

Analysis of the extension strength data shows a variance in Week 2 that is inconsistent as compared to the generally smooth increase in the majority of the data. This anomaly, seen in Table 1.5 and 1.6, can be explained by the activities being run in the exercise program during Week 2. Week 2 largely consisted of trotting, a pace characterized by a strong up and down movement of the horse. In order to remain stabilized on a horse that is trotting, a common practice is employed, known as posting, that involves standing and sitting in the saddle to remain in rhythm with the horse. This repeated action, especially over a prolonged period of time, as was the case during Week 2, serves to strengthen the extensor muscle group. Also, if the foot is turned out at a 45-degree angle, as is customary in correct riding position, the adductor muscles should be strengthened as well. Strengthening of both muscle groups was indeed seen during Week 2.

The trends of the adductor strength data also reveal consistent improvement throughout the course of the study. (Table 1.7 and Table 1.8) This is not surprising due to the fact that the adductor muscles are constantly being employed while riding a horse. In order to remain centered and steady while riding, the inner thighs, or adductor muscles, must be squeezed against the body of the horse. This constant use throughout the exercise programs explains the improvement in adductor strength. On the other hand, I had expected a greater improvement during the final week of the program. Week 5 consisted of riding the horse bareback, without a saddle, for a continuous thirty minutes. Riding a horse bareback requires a great deal of strength in the adductor region, as the rider no longer has the saddle for support but is solely relying on muscle strength to maintain a stable position. Looking for an explanation as to why the surmised increase did not occur, I discovered an important difference in muscle use between the extensors discussed in Week 2 and the adductors in question in Week 5. The extensor muscle group was actively engaged while trotting, as they were in a process of extending and flexing during the session and thus, the muscle contractions were producing movement. Conversely, the adductor muscle group, though also engaged during the exercises, was only active in an isometric manner, as the muscle was contracting against an immovable surface. The adductors were working but not to the degree that the extensors were during trotting; hence, there was not as large of an increase in strength comparatively.

Essentially, it appears that the equine-assisted therapy exercises used in this study are strongly related to the improvements seen in general muscle strength. In fact, the correlation found for the extensors over time was highly positive ($r = 0.95231$). Moreover, the correlation for the adductors was also highly positive ($r = 0.97918$). These vast improvements, in the absence of other knee strengthening activities, serve to encourage the use of equine-assisted therapy for the malalignment-generated patellofemoral syndrome looked at in this study.

Nevertheless, there are improvements to be made in the methodology and data collection of this study. Of course, since this was simply a case study of one subject, it is difficult to determine if similar results will hold for the overall population. However, due to the strong correlations shown over time, I feel confident that improvement is likely in any sector of the population, though, admittedly, the results may not be as drastic. Therefore, in future studies of this subject, it is advisable to expand the subject population, in order to get more applicable results that will perhaps provide an average rate of improvement. Another reason for involving more people in the study is to gain insight into how equine therapy may affect persons with varying degrees of severity regarding patellofemoral syndrome. Since there was only one subject, this study can only necessarily be applied to persons with her level of patellofemoral syndrome. It would also be advisable, in the future, to conduct a follow-up study of subjects to determine whether the benefits seen during the program are maintained over a period of time. Such a study would serve to provide support that animal-assisted therapy is beneficial for more than just short-term improvements. Finally, it would be ideal to find a more reliable method of measuring resistive strength of the vastus medialis obliques. For subjects with severe weakness in the knee region, it doesn't constitute a huge problem because manual muscle testing may be used. However, if the subject has a normal muscle grade but still experiences weakness, as was the case with my subject, other methods must be found. The unreliability of existing machines is a noteworthy impediment to the validation of studies like this one.

As far as limitations to the actual employment of animal-assisted therapy in the rehabilitation market, there are a few more concerns than expected with traditional physical therapy. However, I feel it is important to note that these limitations are only as restrictive as we, the consumers of animal-assisted therapy, allow them to be. That is particularly true, as most of the burden for animal-assisted therapy is likely to fall on the shoulders of the therapists themselves. Potential obstacles include cost, facilities, accessibility, and lack of knowledge.

Cost to the client is always an important concern when considering treatment. However, the concern should not be whether to charge more (or less), but rather how will insurance coverage play a role in animal-assisted therapy. If insurance companies can be persuaded to include this type of therapy in their policies, there should be no reason that cost should be elevated. Especially since, as is true in my case, persons wanting to rehabilitate through animal-assisted therapy are already likely to own animal facilities from the start.

This leads to the next valid point concerning the place of rehabilitation. Animal-assisted therapy requires a much more diverse treatment arena than traditional physical therapy. Traditional physical therapy can take place virtually anywhere, so long as the particular strength machines are accommodated. Animal-assisted therapy, on the other hand, requires space for animal housing, resources to meet nutritional and health needs of the animal, and, of course, space to carry out the therapy, especially critical for equine-assisted therapy. While each of these concerns is indeed relevant, the majority of the burden again falls on the therapist rather than the patient.

Accessibility is also an issue, as with any health care treatment. How accessible animal-assisted therapy is to potential patients basically depends on cost, which was discussed above, and the amount of knowledge the patient has regarding treatment. Lack of understanding about how treatment works or its benefits over traditional physical therapy may impede its utilization. There is generally no skill involved to use animal-assisted therapy instead of traditional physical therapy; the animals are trained for this line of work. Even with equine-assisted therapy, a patient need not be a fantastic rider to experience benefits. Trained personnel can be made available to either stabilize the patient while riding or to actually ride with the patient during treatment. It is the lack of knowledge on the patient's part that is surmised to be the biggest impediment to accessibility in this context.

Conclusions

Despite the obvious limitations to this study due to subject population size and lack of quantitative methods available to gauge resistance and muscle use, it is notable as a starting point for future research into the arena of animal-assisted therapy. The steady correlations found regarding strength improvement are encouraging, since animal-assisted therapy currently lacks quantitative research about physical injuries. The data trends seem to indicate that trotting is most beneficial for the extensors, while the adductors are enhanced at each of the different gaits. As previously mentioned, animal-assisted therapy is largely unresearched except for the short-term physiological and emotional benefits it provides. It is for those exact benefits, however, that I find it necessary to research further into the long-term physical benefits it may have to offer. Many traditional therapy settings lack the encouraging, motivational atmosphere that is such a vital part of rehabilitation. Most exercises require a ball, elastic cord, or a flat surface and can ask for 30-100 repetitions (Student Health Services - Physical Therapy Dept, 2003). These repetitive movements can become tedious unless the person is highly motivated. It is decidedly this exact area that animal-assisted therapy tends to have the edge. When an animal is involved, therapy ceases to be viewed as work, and, instead, enters the realm of interaction or play. In animal-assisted therapy, the animal is the motivation, taking the therapy *with* the patient rather than being an agent of the therapy itself (Grabois et al., 2000). For these reasons, as well as the positive results of this study, animal-assisted therapy warrants more research. Research is needed across more age groups, more injuries, and longer time durations. Essentially, there is hardly a limit to the types of research that can be done and the information that can be found on this increasingly popular form of therapy. In addition to affording people more options when it comes to rehabilitation, research into animal-assisted therapy is both a catalyst and effect of the current times in therapy.

Table 1.1

Potential Causes of Patellofemoral Syndrome
Malalignment
Biomechanical effects:
Altered Q Angle
Pes planus or cavus
Internal tibial rotation
Weakness and atrophy of vastus medialis oblique muscle
Tight lateral retinaculum
Tight iliotibial band
Tight hamstring
Congenital anomalies
Chronic dislocating or subluxing patella
Trauma
Patellar fracture or contusion
Patellar dislocation
Tendon rupture
Reflex sympathetic dystrophy
Overuse
Plica Disorders
Tendinitis
Patellar
Quadriceps femoris
Bursitis
Osteochondritis Dissecans
The Physician and Sportsmedicine, Vol. 22 No. 4 (1994)

Table 1.4

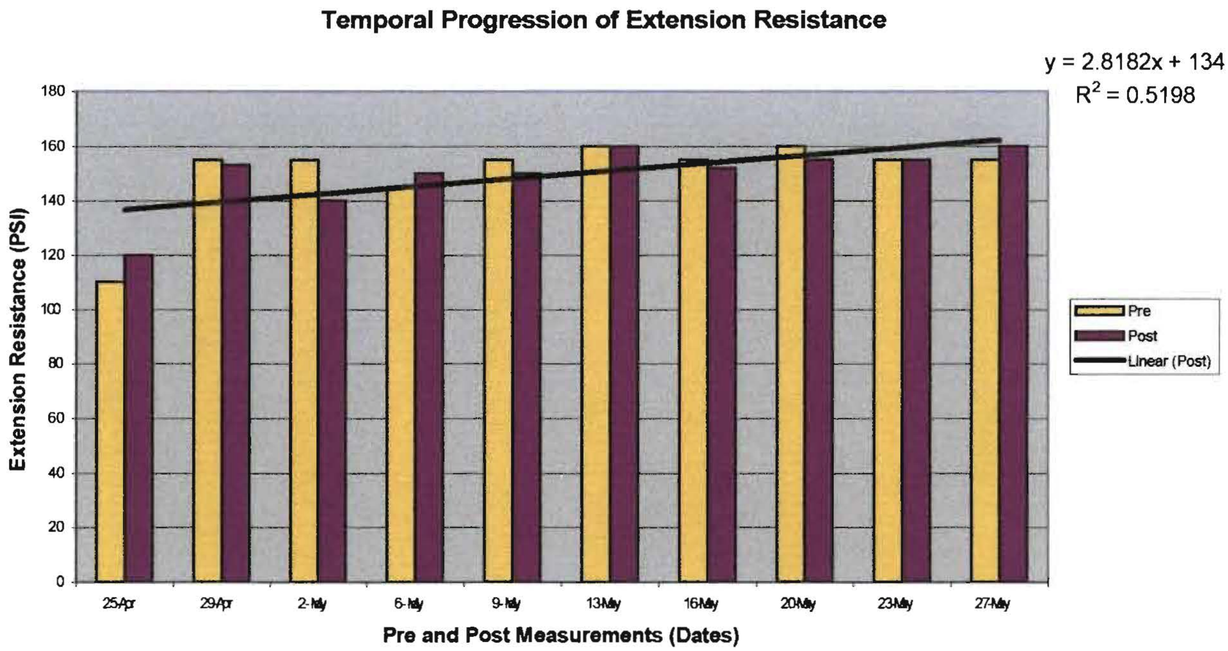


Table 1.5

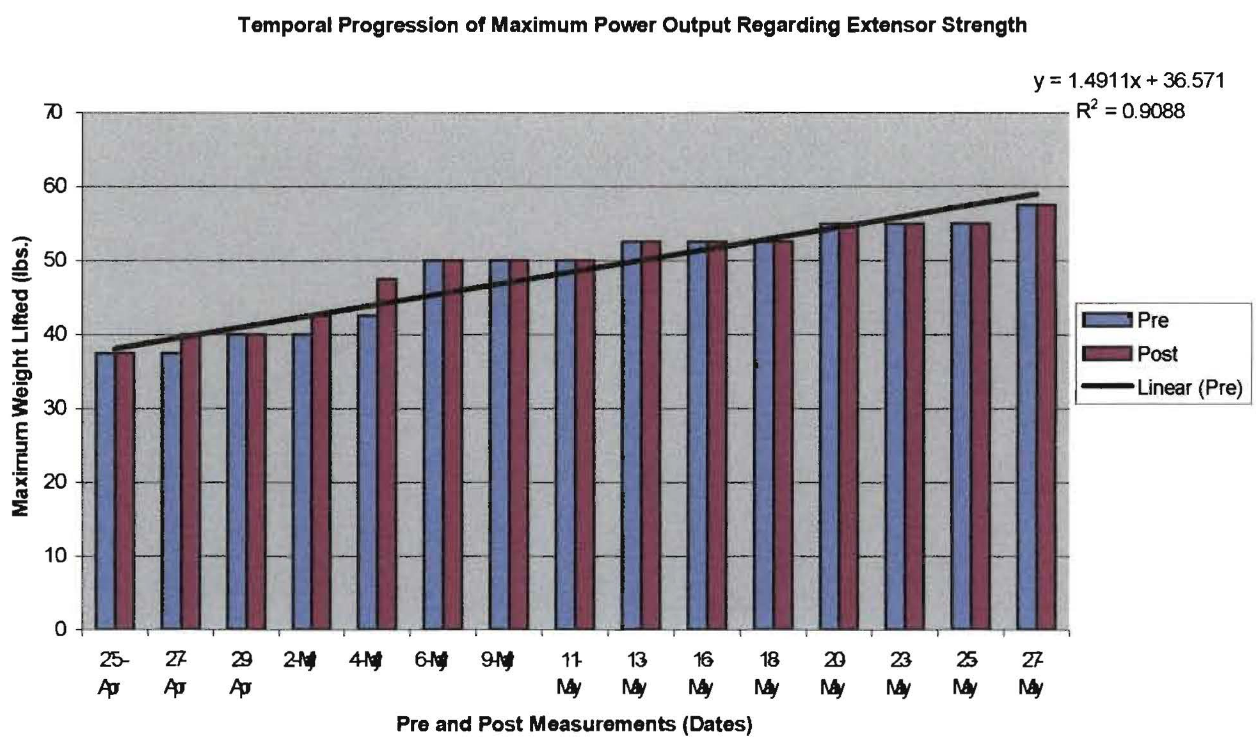


Table 1.6

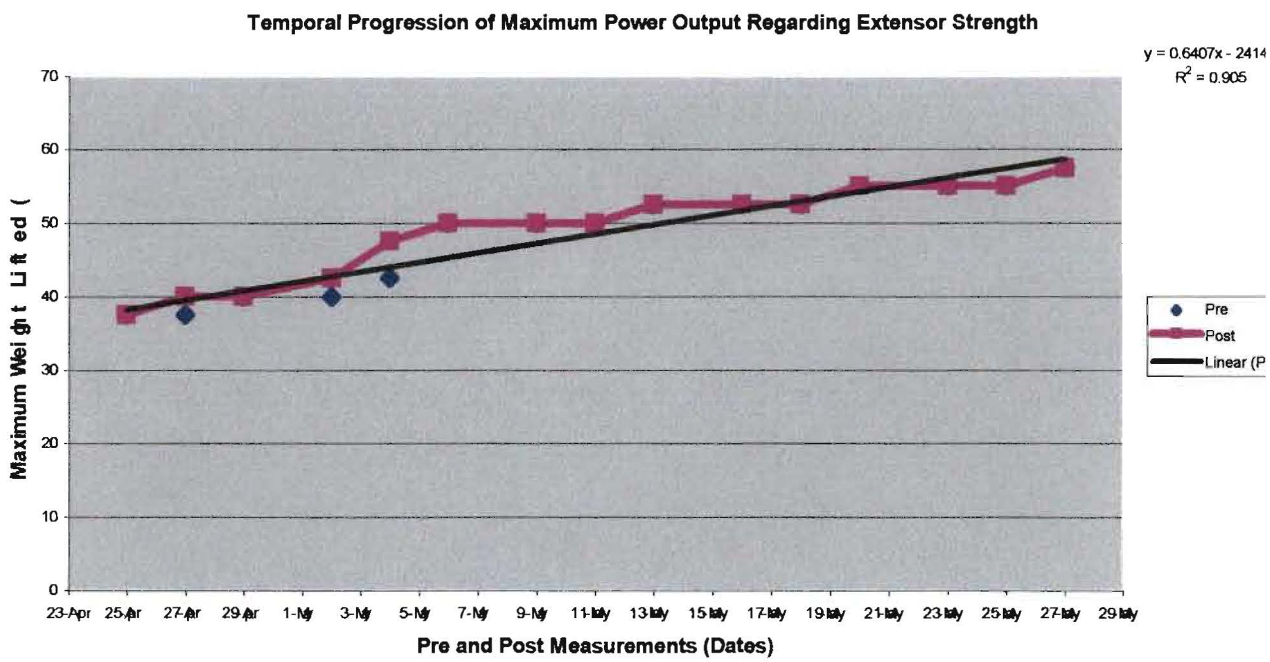


Table1.7

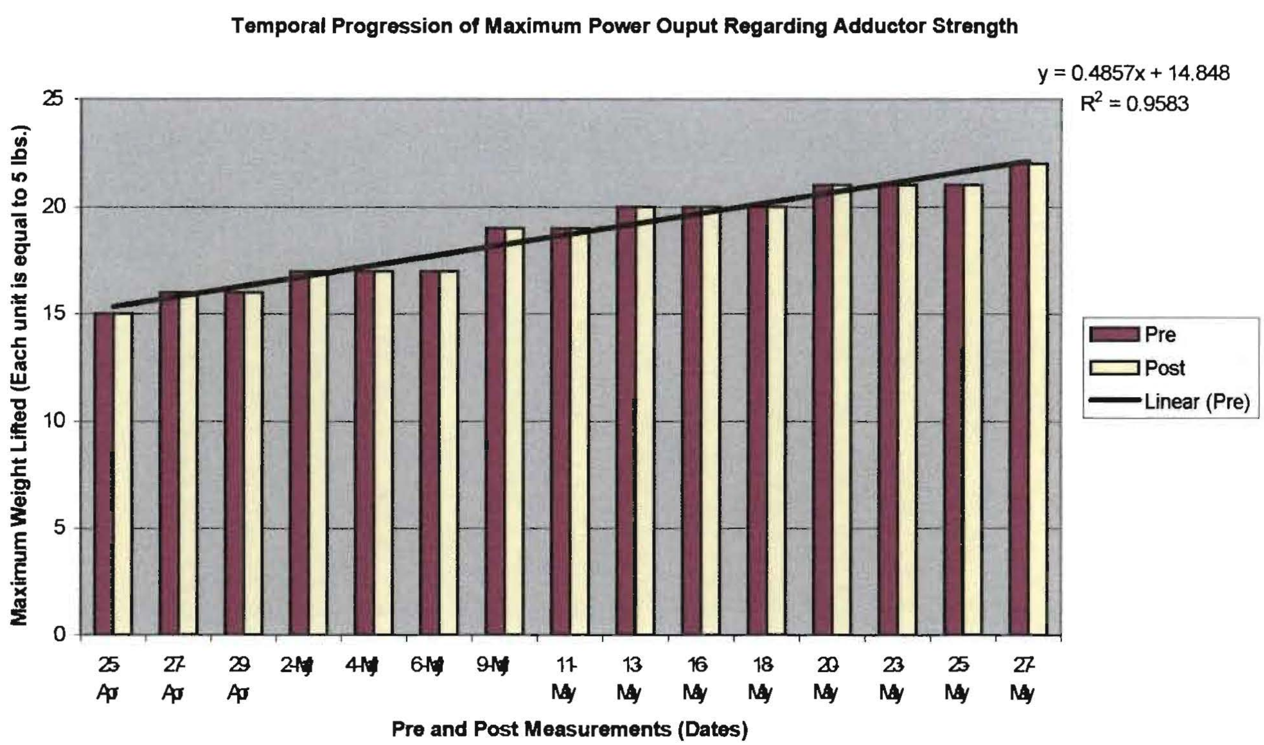
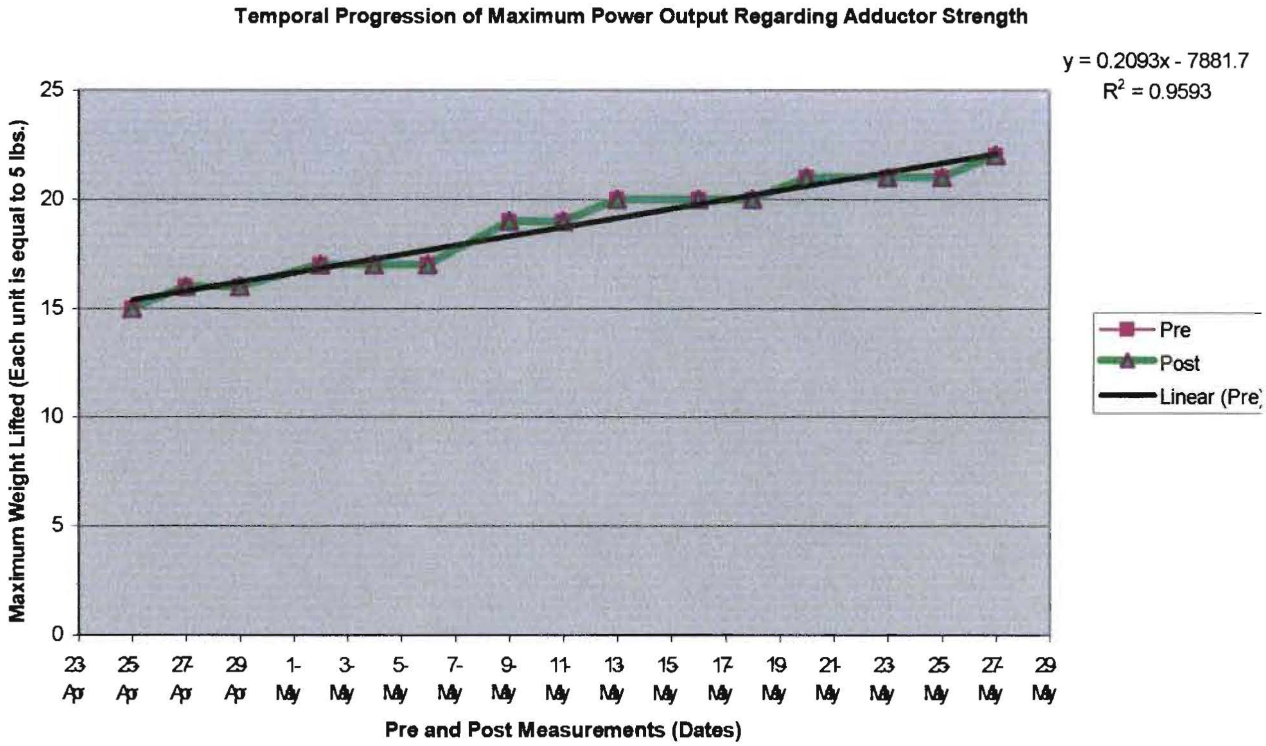


Table 1.8


Temporal Progression of Maximum Power Output Regarding Adductor Strength
y = 0.2093x - 7881.7
R² = 0.9593
Maximum Weight Lifted (Each unit is equal to 5 lbs.)
25
20
15
10
5
0
23 Apr
25 Apr
27 Apr
29 Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
Pre and Post Measurements (Dates)
Pre
Post
Linear (Pre)

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[1] Directions evaluated include linear flexion, linear extension, medial rotation, and lateral rotation.

[2] If the measurements are divided into two sections, a first half and second half, and calculated to give a section average, it is found that extension resistance is nearly 14 PSI higher in the second half relative to the first half.

[3] The graphs depicted in Tables 1.4 and 1.5 present the same extension data points. It is simply given in a different format in order to make certain revelations easier to see. The same situation is true for the adduction data in Tables 1.6 and 1.7.

[4] The stabilization period in these measurements began at the end of Week 1 on April 29th. This is to recognize that there is a "learning curve" when using isokinetic equipment until the body gets use to how it feels. This explains the dramatic jump in data points after the first session.